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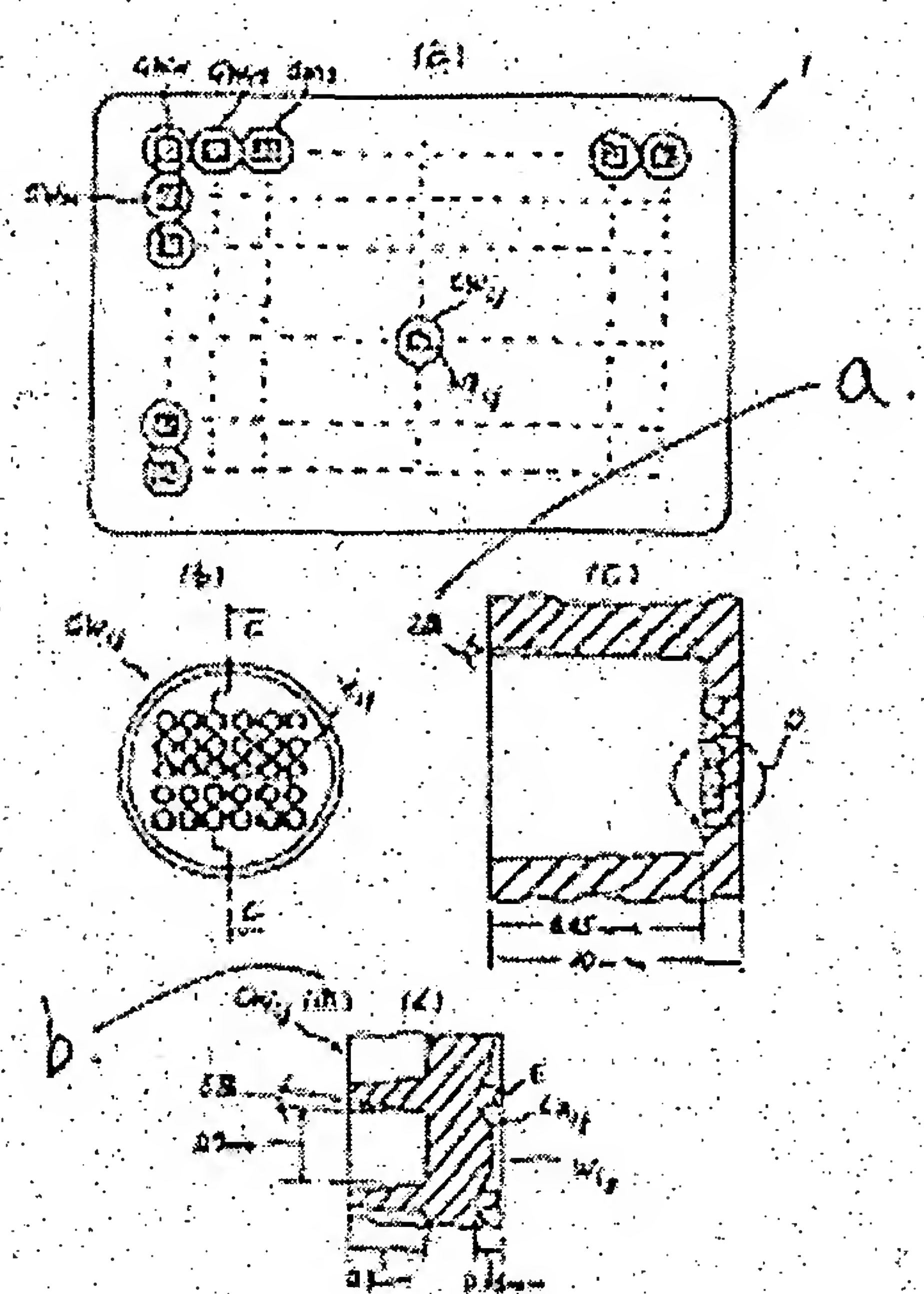
(54) [Title of the Invention] MICROPLATE FOR MEASUREMENT OF LIGHT EMISSION, AND LIGHT EMISSION MEASUREMENT METHOD

(57) [Abstract]

[Object] [The object of the present invention is] to realize a microplate which effectively reduces crosstalk, and which makes it possible to detect and measure extremely weak light emission such as fluorescence or chemoluminescence in an efficient manner.

[Solution] In a microplate in which a plurality of wells W_{ij} used to accommodate light emitting samples are formed in a regular manner according to a specified arrangement, with at least the bottom part of each well being a light-transmitting part, and which is used to measure the light emission in each well via the light-transmitting bottom part, a lens surface Lz_{ij} is formed in the bottom part of each well W_{ij}.



[Key]
a. 2 degrees
b. Degrees

[Claims]

[Claim 1] A microplate used to measure light emission, which is characterized by the fact that in a microplate in which a plurality of wells used to accommodate light-emitting samples are formed in a regular manner according to a specified arrangement, with at least the bottom part of each well being a light-transmitting part, and which is used to measure the light emission in each well via the light-transmitting bottom part, a lens surface which has a positive power is formed in the bottom part of each well.

[Claim 2] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to Claim 1, an opening rim part which is used to reduce crosstalk is formed on the surface on the light emitting side of each well so that the effective diameter of the lens surface is surrounded by the inside wall surface of this opening rim part.

[Claim 3] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to Claim 2, the inside wall surfaces of each opening rim part have a taper with a large taper angle so that the opening diameter increases toward the light emission side.

[Claim 4] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to Claim 2 or Claim 3, a reflective film is formed on the inside wall surfaces of each opening rim part.

[Claim 5] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to Claim 2, Claim 3 or Claim 4, a light-blocking layer is formed on the light-emission end surface part of each opening rim part.

[Claim 6] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to any one of Claims 1 through 5, the respective lens surfaces are formed on the surface on the light emission side.

[Claim 7] A microplate used to measure light emission, which is characterized by the fact that in a microplate in which a plurality of wells used to accommodate light-emitting samples are formed in a regular manner according to a specified arrangement, with at least the bottom part of each well being a light-transmitting part, and which is used to measure the light emission in each well via the light-transmitting bottom part, an opening rim part which is used to reduce crosstalk is formed on the surface on the light emission side of each well so that the diameter of the light emission opening is surrounded by the inside wall surfaces of this opening rim part.

[Claim 8] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to Claim 7, the inside

wall surfaces of each opening rim part have a taper with a large taper angle so that the opening diameter increases toward the light emission side.

[Claim 9] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to Claim 7 or Claim 8, a reflective film is formed on the inside wall surfaces of each opening rim part.

[Claim 10] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to Claim 7 or Claim 8, a light-blocking layer is formed on the light-emission end surface part of each opening rim part.

[Claim 11] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to any one of Claims 1 through 10, numerous wells that are used to accommodate light-emitting samples are divided into groups of n (≥ 2) [wells] each to form well groups, a plurality of large wells are regularly formed according to a specified large well arrangement, and the n wells of one well group are regularly formed according to a specified well arrangement in the bottom part of each large well.

[Claim 12] A microplate used to measure light emission, which is characterized by the fact that in the microplate used to measure light emission according to any one of Claims 1 through 11, the essential parts are formed as molded articles consisting of a transparent resin.

[Claim 13] A light emission measurement method using the microplate according to any one of Claims 1 through 12, which is characterized by the fact that the distance between the incident end surface of an optical fiber which conducts light emitted from the wells to a detection part and the bottom surface of the microplate is maintained at a specified distance, and the switching of the wells is accomplished by displacing [the optical fiber] relative to the above-mentioned microplate.

[Claim 14] A light emission measurement method which is characterized by the fact that in the light emission measurement method according to Claim 13, [the microplate] is used with a very small positive lens used to increase the light-gathering properties fastened to the incident end surface of the optical fiber.

[Claim 15] A light emission measurement method which is characterized by the fact that in the light emission measurement method according to Claim 14, a microplate in which a lens with a positive power and an opening rim part used to reduce crosstalk are formed for each well is used as the microplate.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention relates to a microplate used to measure light emission and a light emission measurement method.

[0002]

[Prior Art] Light emission measurement is known in which "fluorescent samples that emit fluorescent light induced by exciting light" or "chemoluminescent samples that emit light induced by a chemical reaction" are accommodated in the respective wells of a microplate in which small wells (hollows) are formed, these samples are caused to emit light, and the light that is emitted is measured on the side of the bottom part of the microplate. For example, the apparatus described in Japanese Patent Application Kokai No. H10-281994 is known as a fluorescent light measuring apparatus which measures the emission of fluorescent light generated by exciting light.

[0003] Fluorescent light or chemoluminescent light generated inside wells is generally extremely weak; accordingly, the efficient detection and measurement of such extremely weak light is a problem.

[0004] Furthermore, since fluorescent light and chemoluminescent light have no directionality, the problem of so-called "crosstalk," in which light from nearby wells is mixed with the light that is to be detected so that the S/N ratio of the detection signal is lowered, cannot be ignored.

[0005]

[Problems to Be Solved by the Invention] One object of the present invention is to realize a novel microplate which makes it possible to achieve an effective reduction in crosstalk. Furthermore, another object of the present invention is to realize a novel microplate which makes it possible to detect and measure extremely weak fluorescent light and chemoluminescent light in an efficient manner.

[0006] Furthermore, still another object of the present invention is to realize a light emission measurement method using the above-mentioned novel microplate.

[0007]

[Means Used to Solve the Above-mentioned Problems] The microplate of the present invention is "a microplate in which a plurality of wells used to accommodate light-emitting samples are formed in a regular manner according to a specified arrangement, with at least the bottom part of each well being a light-transmitting part, and which is used to measure the light emission in each well via the light-transmitting bottom part." The emitted light that is the object of measurement is "fluorescent light or chemoluminescent light, etc."

[0008] The microplate according to Claim 1 is characterized by the fact that "a lens surface which has a positive power is formed in the bottom part of each well." In regard

to the light that is emitted inside the wells, as was described above, the light that is transmitted through the light-emitting bottom part of each well is measured. As a result of the [above-mentioned] positive power, the lens surface formed in the bottom part of each well is endowed with a directionality in which "random diffusion" is suppressed. Accordingly, efficient detection is possible.

[0009] An "opening rim part which is used to reduce crosstalk" can be formed on the surface of each well on the light emission side in the microplate used to measure light emission according to Claim 1 (Claim 2). This "opening rim part" is formed so that the inside wall surface of this part surrounds the effective diameter of the lens surface.

[0010] In cases where opening rim parts are thus formed, the inside wall surfaces of the opening rim parts may be given "a taper with a large taper angle so that the opening diameter increases toward the light emission side" (Claim 3). Such a "taper with a large taper angle" refers to a taper with a taper angle of 10 degrees or greater, preferably 15 degrees or greater. For example, in cases where the microplate is formed as a resin molding, the above-mentioned taper with a large taper angle "facilitates" removal from the mold.

[0011] The opening rim parts effectively reduce the "generation of crosstalk in the direction of adjacent wells by light emitted from the bottom part of [each] well." In the microplate used to measure light emission according to the above-mentioned Claim 2 or Claim 3, which has such opening rim parts, it is possible to "form a reflective film on the inside wall surfaces of each opening rim part" in order to increase the effect of the opening rim parts in reducing crosstalk (Claim 4). Such a reflective film also enhances the directionality (provided by the lens surfaces) of the light emitted from each well.

[0012] In the microplate used to measure light emission according to the above-mentioned Claim 2, Claim 3 or Claim 4, it is also possible to "form a light-blocking layer on the light-emission end surface part of each opening rim part" in order to achieve a further reduction in crosstalk (Claim 5).

[0013] In the microplate used to measure light emission according to any one of the above-mentioned Claims 1 through 5, the "lens surface with a positive power" which is formed on the bottom surface of each well may be formed on the inside and/or outside of the bottom surface of the well; however, from the stand point of ease of molding of the lens surface, it is desirable that the lens surface be formed on the outside of the bottom part of the well, i. e., on the "surface located on the light emission side."

[0014] The microplate according to Claim 7 is characterized by the fact that the opening rim part used to reduce crosstalk is formed on the light-emission-side surface of each well so that the diameter of the light emission opening is surrounded by the inside wall surfaces of this opening rim part. Specifically, in this case, no lens surface is formed.

[0015] In this microplate used to measure light emission according to Claim 7, the inside wall surfaces of the opening rim parts may be given a "tape with the above-mentioned

large taper angle so that the opening diameter increases in the direction of light emission." Furthermore, in the microplate used to measure light emission according to Claim 7 or Claim 8, a reflective film may be formed on the inside wall surfaces of each opening rim part (Claim 9).

[0016] Since the microplate described in Claim 7 or Claim 8 has no lens surfaces, no directionality created by lens surfaces is imparted to the light that is emitted from the wells; however, the reflective film formed on the inside wall surfaces of the above-mentioned opening rim parts imparts a slight directionality to the light that is emitted from the wells, so that the efficiency of detection of the emitted light is enhanced.

[0017] In particular, if a reflective film is formed on the inside wall surfaces of opening rim parts in which a taper with a large taper angle is formed, a directionality is imparted to light that tends to cause crosstalk, so that crosstalk can be effectively reduced. The same is true in the case of the microplate according to Claim 4

[0018] Furthermore, in the microplate used to measure light emission according to Claim 7, Claim 8 or Claim 9 as well, the reduction of crosstalk can be aided by forming a light-blocking layer on the end surface portion of each opening rim part located on the light emission side.

[0019] In the microplate used to measure light emission according to any one of the above-mentioned Claims 1 through 10, a plurality of wells can of course be formed in a uniform arrangement over "all of a specified area" of the microplate; however, it is also possible to divide the numerous wells into "groups consisting of a fixed number of wells each" as in the microplate according to Claim 1.

[0020] Specifically, in the microplate according to Claim 11, the numerous wells used to accommodate light-emitting samples are divided into groups of n (≥ 2) wells each to form "well groups."

[0021] Meanwhile, a plurality of large wells are regularly formed according to a specified "large well arrangement," and the n wells of one well group are regularly formed according to a specified "well arrangement" in the bottom part of each large well.

[0022] In the microplate used to measure light emission according to any one of the above-mentioned Claims 1 through 11, the essential parts may be formed as molded parts consisting of a transparent resin (Claim 12). Here, the term "essential parts of the microplate" refers to the parts other than the above-mentioned reflective film and light blocking layer.

[0023] The light emission measurement method of the present invention is a light emission measurement method which uses the microplate according to any one of the above-mentioned Claims 1 through 12; this method is characterized by the fact that "the distance between the incident end surface of an optical fiber which conducts light emitted from the wells to a detection part and the bottom surface of the microplate is maintained

at a specified distance, and the switching of the wells is accomplished by displacing [the optical fiber] relative to the microplate" (Claim 13).

[0024] In the case of this light emission measurement method according to Claim 13, it is possible to "use [the microplate] with a very small positive lens that is used to increase the light-gathering properties fastened to the incident end surface of the optical fiber" (Claim 14). In this case, it is further possible to use "as the microplate a microplate in which a lens with a positive power and an opening rim part used to reduce crosstalk are formed for each well" (Claim 15).

[0025] Of course, in cases where the respective microplates described above are used, it would also of course be possible to devise the system so that the light emitted from the respective wells is simultaneously detected using a plurality of optical fibers. Furthermore, in cases where the microplate according to Claim 11 is used, it would be possible to devise the system so that "the light emitted in n wells within one large well is simultaneously detected by a plurality of optical fibers, and switching of the large wells is accomplished displacing the above-mentioned plurality of optical fibers as an integral unit relative to the microplate."

[0026] Alternatively, using the microplate according to Claim 11, it would also be possible to use a single optical fiber for each large well, to simultaneously detect the light emitted in single wells for each large well, and to accomplish the switching of wells within each large well by displacing a plurality of optical fibers as an integral unit relative to the microplate.

[0027]

[Working Configurations of the Invention] Figure 1 shows diagrams which are used to illustrate a first working configuration of the microplate of the present invention. The microplate 1 used to measure light emission is the microplate according to Claim 11, with the essential parts [of this microplate] being formed as molded parts consisting of a transparent resin (Claim 12).

[0028] Figure 1 (a) is a plan view of the microplate 1. The microplate 1 is a plate-form part with four rounded corners, and is formed as a molded part; accordingly, the circumferential edge part is tapered at a taper angle of 2 degrees for "mold release." Furthermore, in regard to the size of the microplate 1, the width in the lateral direction is 128 mm, the width in the longitudinal direction is 86 mm, and the thickness is 10 mm.

[0029] Large wells GW_{11}, GW_{12}, GW_{13}, ... GW_{21}, ... GW_{ij}, ... are formed in the form of a matrix according to a large well arrangement in the microplate 1. The respective large wells GW_{ij} have the same shape. In concrete terms, these large wells have a circular shape with a diameter of 8 mm on the side facing the viewer of the figures. A total of 96 large wells are formed, with 12 large wells being formed in the lateral direction of the figure, and 8 large wells being formed in the longitudinal direction of the figure, at a pitch of 9 mm.

[0030] The inside walls of the large wells GW_{ij} are tapered at a taper angle of 2 degrees for purposes of mold release. Furthermore, well groups wg_{ij} are formed in the bottom parts of the respective large wells GW_{ij}. Figure 1 (b) shows a plan view of an arbitrary large well GW_{ij}, and Figure 1 (c) shows a sectional view along line C-C in Figure 1 (b).

[0031] As is shown in Figure 1 (c), the large wells GW_{ij} have a depth of 8.45 mm from the opening parts (left side in the figure) to the bottom parts, and the inside wall surfaces are tapered at a taper angle of 2 degrees as described above.

[0032] In the well group wg_{ij} formed in the bottom part of each large well GW_{ij}, as is shown in Figure 1 (b), wells W_{ij} used to accommodate light-emitting samples are arranged in a regular manner. The wells W_{ij} have the same shape, i.e., a circular shape seen in a plan view. As is shown in the figures, the arrangement of the wells W_{ij} that make up each well group (the well arrangement) is a matrix-form arrangement; 30 wells are formed with 6 wells arranged in the lateral direction of the figure, and 5 wells arranged in the longitudinal direction, for a total of 30 wells. The pitch at which these wells W_{ij} are lined up is 1 mm in both the longitudinal and lateral directions.

[0033] Figure 1 (d) shows an enlargement of the portion indicated by D in Figure 1 (c), and shows the cross-sectional shape of the individual wells W_{ij}. The individual wells W_{ij} are bored into the bottom parts GW_{ij} [sic] (bottoms) of the large wells GW_{ij}; the diameter of the bottom part (with a circular shape) of each well W_{ij} is 0.7 mm, the depth is 0.8 mm, and the taper angle of the taper on the inside walls is 5 degrees.

[0034] Lens surfaces Lz_{ij} of the same shape are formed for each well on the side of the light emission surface (right-side surface in Figure 1 (d)) of the bottom part of each well W_{ij}. These lens surfaces Lz_{ij} have a convex surface and a positive power; the lens surfaces in the present description have a curvature radius of 0.6 mm and an effective lens diameter of 0.8 mm.

[0035] Furthermore, an opening rim part E which is used to reduce crosstalk is formed so that this part surrounds the effective diameter of each lens surface Lz_{ij}. The height of this opening rim part E is 0.25 mm, and a taper used for mold release is formed with a taper angle of 5 degrees on the inside wall surfaces of this opening rim part E so that the opening increases in size toward the light emission side. The well groups wg_{ij} formed in the large wells GW_{ij} are all identical. The opening shape of the opening rim parts E is a circular shape as seen from the right side in Figure 1 (d).

[0036] Furthermore, in the working configuration shown in Figure 1, each well W_{ij} is small, with a diameter of 0.7 mm and a depth of 0.8 mm; accordingly, these wells might also be called "micro-wells" or "micro-cells" instead of wells. The lens surfaces Lz_{ij} are also small, with an effective lens diameter of 0.8 mm, and therefore might also be called "micro-lens surfaces."

[0037] Specifically, the microplate 1 described in the working configuration shown in Figure 1 is a microplate in which a plurality of wells W_{ij} used to accommodate light-emitting samples are regularly formed according to a specified arrangement, with at least the bottom parts of the respective wells being light-transmitting parts, and this microplate is used to measure the light emitted in the respective wells via the light-transmitting bottom parts of the wells; in this microplate, furthermore, a lens surface Lz_{ij} which has a positive power is formed in the bottom part of each well W_{ij} (Claim 1). Furthermore, in this microplate, an opening rim part E which is used to reduce crosstalk is formed on the light-emitting-side surface of each well W_{ij} so that this opening rim part E surrounds the effective diameter of the lens surface Lz_{ij} on the inside wall surfaces (Claim 2). Moreover, the respective lens surfaces Lz_{ij} are formed on the light-emitting surface side [of each well] (Claim 6).

[0038] Furthermore, in this microplate, the numerous wells that are used to accommodate light-emitting samples are divided into groups of n (= 30) wells each so that well groups wg_{ij} are formed, a plurality of large wells GW_{ij} are regularly formed according to a specified large well arrangement, and the n wells W_{ij} of one well group are regularly formed according to a specified well arrangement in the bottom part of each large well GW_{ij} (Claim 11).

[0039] Figures 2 and 3 show well configurations (types) that can be formed in the microplate of the present invention. Types a through g shown in Figure 2 are types of wells that belong to the microplate of Claim 6.

[0040] Type a is a type in which "a lens surface Lz that has a positive power is formed on the light-emitting surface side in the bottom part of each well." Type b is a type in which "a lens surface Lz that has a positive power and an opening rim part E are formed on the light-emitting surface side in the bottom part of each well" (Claim 2). Type c is a type in which "an opening rim part E1 which has a taper with a large taper angle so that the opening diameter increases in the direction of light emission (toward the bottom in the figure)" is formed as the [above-mentioned] opening rim part (Claim 3). The respective wells in the working configuration shown in Figure 1 belong to type c.

[0041] Type d is a type in which a reflective film Rf is formed by vacuum evaporation on the inside wall surfaces of the opening rim part E in type b (Claim 4). Type e is a type in which a light-blocking layer S is formed on the light-emitting end surface portion of the opening rim part E in type d (Claim 5). For example, this light-blocking layer S can be formed by "coating or printing with black ink."

[0042] Type f is a type in which a reflective film Rf is formed on the inside wall surfaces of the opening rim part E1 in type c (Claim 4). Type g is a type in which a light-blocking layer S is formed on the light-emitting end surface portion of the opening rim part E1 in type f (Claim 5).

[0043] The wells types h through m shown in Figure 3 are well types formed in the microplates according to Claims 7 through 10. Type h is a type in which "an opening rim

part E that is used to reduce crosstalk is formed on the light-emitting-side surface of each well so that the diameter of the light-emitting opening is surrounded by the inside wall surfaces of this opening rim part (Claim 7)." Type i is a type in which "an opening rim part E1 that is used to reduce crosstalk is formed on the light-emitting-side surface of each well so that the diameter of the light-emitting opening is surrounded by the inside wall surfaces of this opening rim part, and the inside wall surfaces of the opening rim part E1 have a taper with a large taper angle so that the diameter of the opening increases in the direction of light emission (Claim 8)."

[0044] Type j is a type in which a reflective film Rf is formed on the inside wall surfaces of the opening rim part E in type h (Claim 9), and type k is a type in which a reflective film Rf1 is formed on the inside wall surfaces of the opening rim part E1 in type i (Claim 9).

[0045] Furthermore, type l is a type in which a light-blocking layer S is formed on the emitting-side end surface portion of the opening rim part E in type j (Claim 10), and type m is a type in which a light-blocking layer S is formed on the emitting-side end surface portion of the opening rim part E1 in type k (Claim 10).

[0046] Figures 4 and 5 are diagrams which illustrate embodiments of the light measurement method. In these figures, the symbol 10 indicates a microplate, the symbol WL indicates wells, and the symbol FB indicates an optical fiber. Furthermore, in Figure 5, the symbol ML indicates a "very small positive lens."

[0047] In the microplate 10, as is shown in Figures 4 and 5, a plurality of wells WL that are used to accommodate light-emitting samples 0 are regularly formed according to a specified arrangement. At least the bottom part of each well is a light-transmitting part, and the microplate is arranged so that the light emitted in each well is measured via the light-transmitting bottom part. A lens surface Lz which has a positive power is formed in the bottom part of each well WL.

[0048] A light-emitting sample 0 is accommodated in each well WL, and a reagent is supplied from the upper part of each well WL. When the reagent contacts the light-emitting sample inside each well WL, "chemoluminescent light" or "fluorescent light" is emitted.

[0049] In the light emission measurement method shown in Figure 4, the switching of wells WL is accomplished by displacing the optical fiber FB (which is used to conduct light emitted from the wells WL to a detection part) relative to the microplate 10 while maintaining the distance between the incident end surface (the end surface on the side of the microplate) [of this optical fiber FB] and the bottom surface of the microplate at a specified distance.

[0050] In the light emission measurement method shown in Figure 5, the apparatus is used with a very small positive lens ML that is used to increase the light-gathering properties when fastened to the incident end surface of the optical fiber FB.

[0051] As is shown in Figures 4 and 5, the light emitted from each well can be measured by performing a light detection operation in which the arrangement of wells WL in the microplate 10 is "scanned" by the optical fiber FB.

[0052] To cite "gene detection by the hybridization method" as one example of measurement, in Figure 4 or 5, respectively different oligo-probes (DNA having a base length of several bases to several tens of bases, whose base sequence is known beforehand) are accommodated in the respective wells WL of the microplate 10, and a "reagent liquid containing a target nucleic acid labeled with a fluorescent molecule" is supplied to the wells as a reagent. When the target nucleic acid in the sample liquid bonds with the oligo-probe, fluorescent light is emitted.

[0053] Accordingly, in the method shown in Figure 4 or 5, well scanning is performed by means of the optical fiber FB, and if a well WL emitting fluorescent light is specified, it is known that the target nucleic acid has the base sequence of the oligo-probe accommodated in this well. Thus, the base sequences contained in the target nucleic acids in the sample liquids can be efficiently ascertained.

[0054]

[Embodiments] The present inventors performed a simulation to evaluate the characteristics of light emission measurement in a case using the microplate of the present invention. The conditions of this simulation were as follows: [first,] a microplate similar to that described in Figure 1 was envisioned as the microplate used. Specifically, a microplate formed from a resin material (polycarbonate, refractive index of 1.562498 with respect to light at a wavelength of 520 nm) was envisioned. Wells of the various types shown in Figures 2 and 3 were envisioned as the wells used. Figure 6 shows four types of wells and the positional relationships with the optical fiber FB as examples. The well indicated as Ref was "used for comparison"; types a, b and c are all types that were illustrated in Figure 2.

[0055] The well Ref was a circular well in which the diameter of the well bottom surface was 0.7 mm; the shape of this bottom surface was the same as those of the wells of the other types. Furthermore, the thickness of the bottom part of the well in the well Ref (distance from the bottom part of the well to the emitting surface) was 0.75 mm.

[0056] In types b and c and types d through g in Figure 2 as well, the heights of the top parts of the lens surfaces Lz and the light-emitting side end surface parts of the opening rim parts E or E1 were the same. In all of types a through g, the distance from the bottom part of the well to the top part of the lens surface or light-emitting side end surface part was equal to the thickness of the bottom part (0.75 mm) in well Ref.

[0057] Furthermore, in types h through m shown in Figure 3, which had only an opening rim part E or E1, and did not have a lens surface, the distance from the bottom part of the

well to the emitting side end surface part of the opening rim part was equal to the thickness of the bottom part (0.75 mm) in well Ref.

[0058] In types a through g, the curvature radius of the lens surface Lz was set at 0.6 mm, and the lens thickness was set at 0.25 mm. In types a through m, the height of the opening rim part was set at 0.25 mm. Furthermore, in all types of the wells, the end surface of the optical fiber FB was positioned so that the distance from the above-mentioned top part of the lens surface or the emitting side end surface part of the opening rim part (distance DS in Figure 6) was 0.3 mm, and the central axis of the optical fiber was caused to coincide with the central axis of the well.

[0059] "Fluorescent light at a wavelength of 520 nm" was envisioned as the type of light emission. It was assumed that this fluorescent light was surface emission at a uniform light intensity in the bottom portion of each well, and it was assumed that the fluorescent light emitted as surface light emission was completely diffused light. The quantity of light (X%) emitted via the optical fiber FB where the quantity of light emitted per unit time in the above-mentioned uniform light emission at the bottom surface of each well was taken as 100% (since the light was completely diffused light, the light propagated to the side of the optical fiber was 50%) was defined as the "light gathering efficiency," and this light gathering efficiency X was determined by simulation.

[0060] Furthermore, the quantity of light Y% detected by the optical fiber FB in the case of light emitted by adjacent wells was determined as the "crosstalk." As is shown in Figure 1 (b), the well arrangement was a square matrix arrangement, with one well being surrounded by eight adjacent wells. Accordingly, a light quantity of 8Y% was determined as the maximum value of the above-mentioned crosstalk, and the ratio of the light quantity X to the light quantity 8Y, i. e., X/(8Y), was determined as the "S/N ratio."

[0061] Typical examples of the simulation results are listed below, with the well type Ref being shown on the left side of Figure 6, and the other types being shown in Figures 2 and 3. Furthermore, the taper angle of the inside wall portions of the opening rim part E1 in types c, f, g and i was 22.5 degrees, the reflectivity of the reflective film Rfl in types f and g was 100%, and the transmissivity of the light-blocking layer S in type g was 0%.

[0062] A plastic optical fiber with a core diameter of 735 μm and an external diameter of 750 μm (refractive index of core part: 1.495342, refractive index of cladding part: 1.422831) was envisioned as the optical fiber used.

[0063]

[Simulation Results]

Type of well	Light gathering efficiency X	Crosstalk Y	8Y	S/N
Ref	7.7	0.9	7.2	1.07
Type: a	9.7	0.7	5.6	1.73

Type: b	9.6	0.5	4.0	2.40
Type: c	9.7	0.6	4.8	2.02
Type: h	7.8	0.5	4.0	1.95
Type: i	7.7	0.6	4.8	1.61
Type: f	11.6	0.6	4.8	2.42
Type: g	11.6	0.5	4.0	2.90

[0064] As is clear from these results, the light gathering efficiency is increased by approximately 2% compared to the Ref type well by forming a lens surface on the bottom surface of the well (types a, b and c). As is seen from a comparison of types b, h and i with the Ref type well, the formation of an opening rim part results in a drop of 0.3 to 0.4% in crosstalk.

[0065] As is seen from a comparison of types c, i, f and g with the Ref type well, the formation of a "taper with a large taper angle" in the inside wall surfaces of the opening rim part, and the formation of a light-blocking layer on the emitting side end surface part of the opening rim part, have a crosstalk lowering effect, and the formation of a reflective film on the above-mentioned inside wall surfaces has an effect in increasing the light gathering efficiency.

[0066] The present inventors also performed a simulation similar to that described above for a case in which a microplate having wells of the above-mentioned type b was envisioned, and "a very small positive lens ML used to increase the light gathering characteristics was fastened to the incident end surface of the optical fiber FB" as shown in Figure 5. The optical fiber was the same plastic optical fiber as that described above.

[0067] A lens with an paraxial curvature radius of 0.4 mm, a non-spherical coefficient (conical constant) K of –0.43, a lens thickness of 0.9 mm, an effective diameter of 0.9 mm and a lens material consisting of a polycarbonate was envisioned as the positive lens ML. The emitting end surface (plane) of this lens was fastened to the end surface of the optical fiber, and a simulation was performed with the spacing between the top part of the lens ML and the top part of the lens surface Lz on the side of the microplate set at 0.3 mm. The following results were obtained.

Well type	Light gathering efficiency X	Crosstalk Y	8Y	S/N
Type b	6.50	0.14	1.14	5.68

When these results are compared with the case of the above-mentioned type b in which "a positive lens ML was not used," it is seen that when a positive lens ML is used, the light gathering efficiency X drops by as much as 3.1% compared to a case where a positive lens ML is not used; however, since the crosstalk Y is greatly reduced (by 0.36%), the resulting S/N ratio is increased by approximately 2.4 times, from 2.4 to 5.68. In other words, the fastening of a positive lens to the end surface of the optical fiber has the effect of increasing the S/N ratio.

[0068]

[Effect of the Invention] As was described above, the present invention makes it possible to realize a novel microplate and light emission measurement method. The use of the present invention allows the effective reduction of crosstalk, and the efficient detection and measurement of extremely weak emitted light such as fluorescent light and chemoluminescent light. Furthermore, the "opening shape of the opening rim part" is not limited to the above-mentioned round shape; polygonal shapes such as square or hexagonal shapes, etc., may also be used.

[Brief Description of the Drawings]

[Figure 1] Figure 1 is a diagram which is used to illustrate one working configuration of the microplate.

[Figure 2] Figure 2 shows diagrams which illustrate types of wells formed in the microplate.

[Figure 3] Figure 3 shows diagrams which illustrate types of wells formed in the microplate.

[Figure 4] Figure 4 is a diagram which is used to illustrate the light emission measurement method.

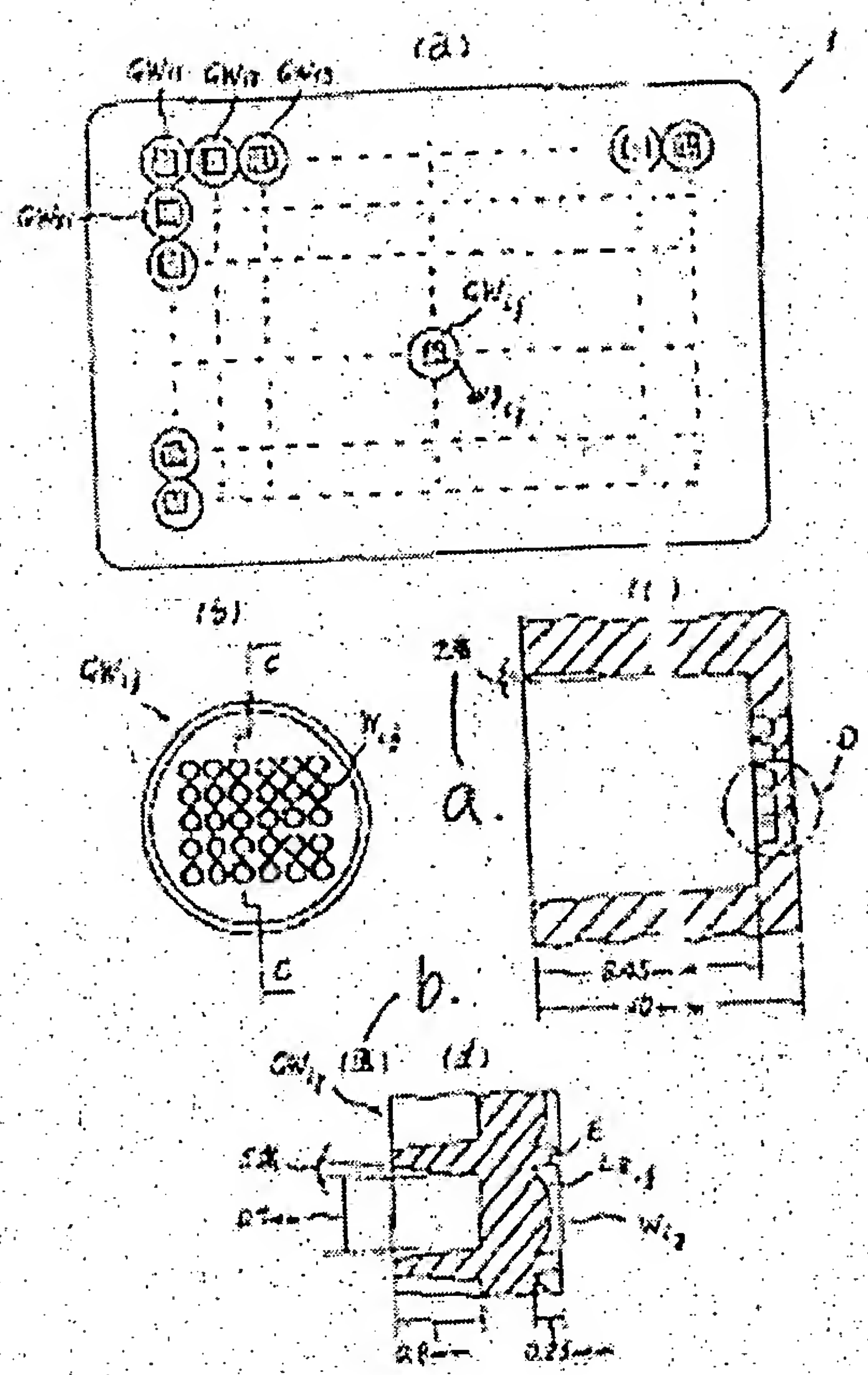
[Figure 5] Figure 5 is a diagram which is used to illustrate the light emission measurement method.

[Figure 6] Figure 6 is a diagram which is used to illustrate the conditions of the simulation.

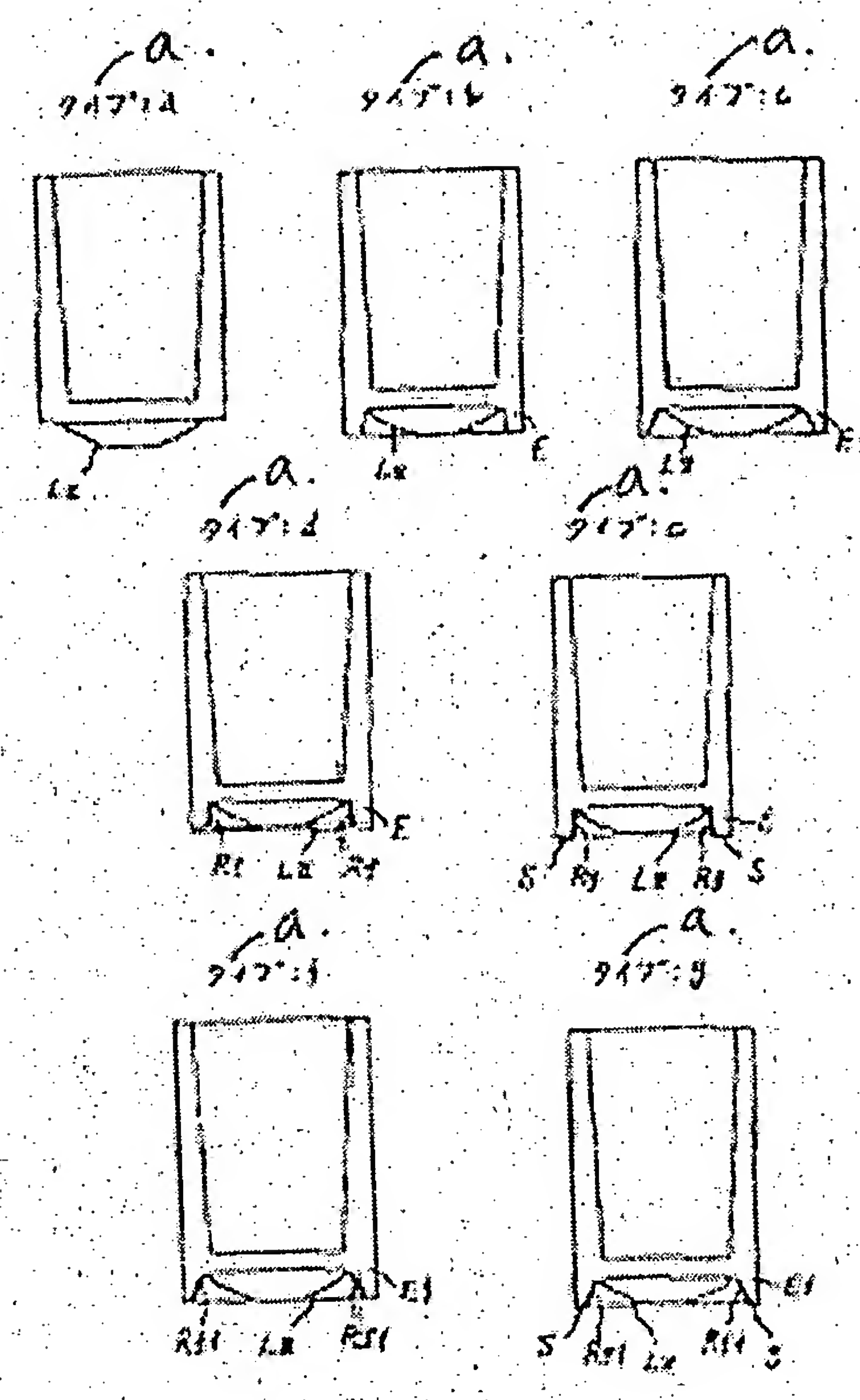
[Explanation of Symbols]

1 Microplate
GW_{ij} Large wells
wg_{ij} Well groups
W_{ij} Wells
E Opening rim parts

[Fig. 1]



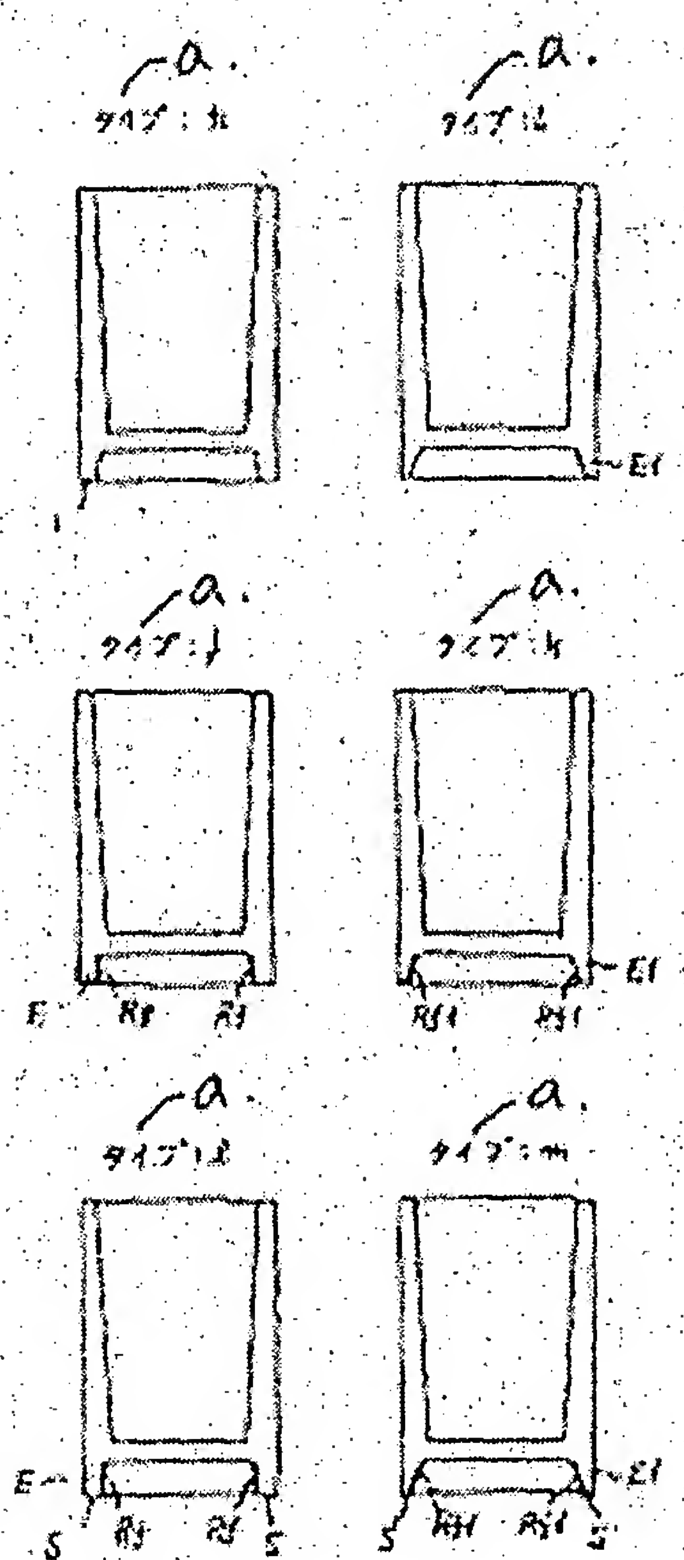
[Fig. 2]



[Key]
a. 2 degrees
b. Degrees

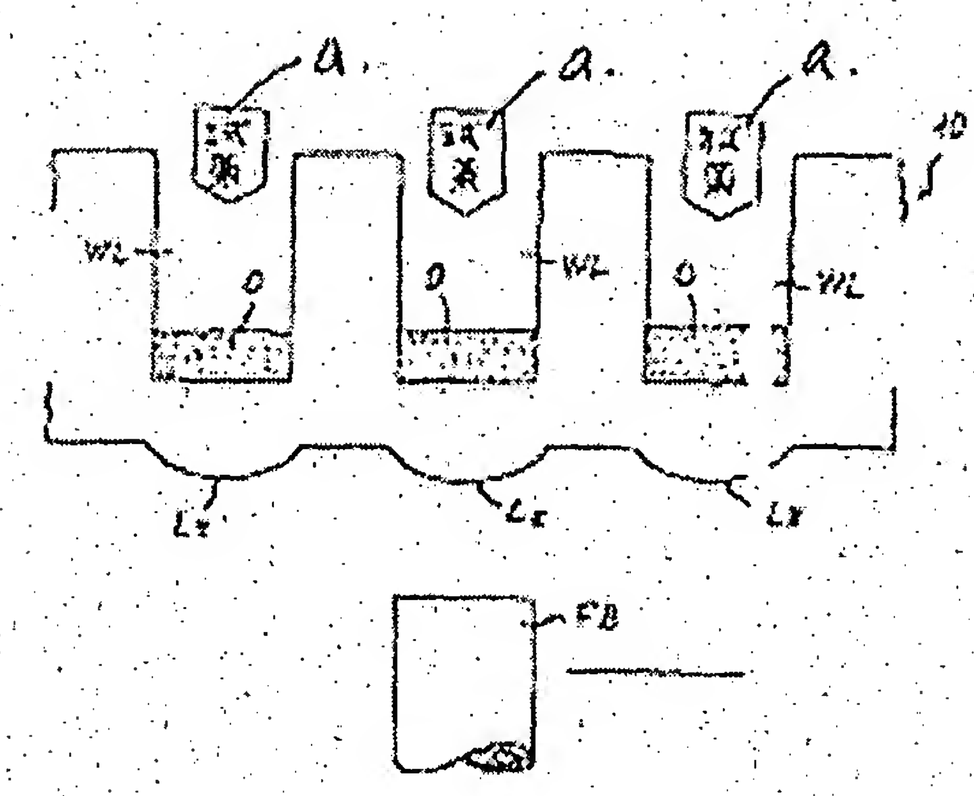
[Key]
a. Type

[Fig. 3]



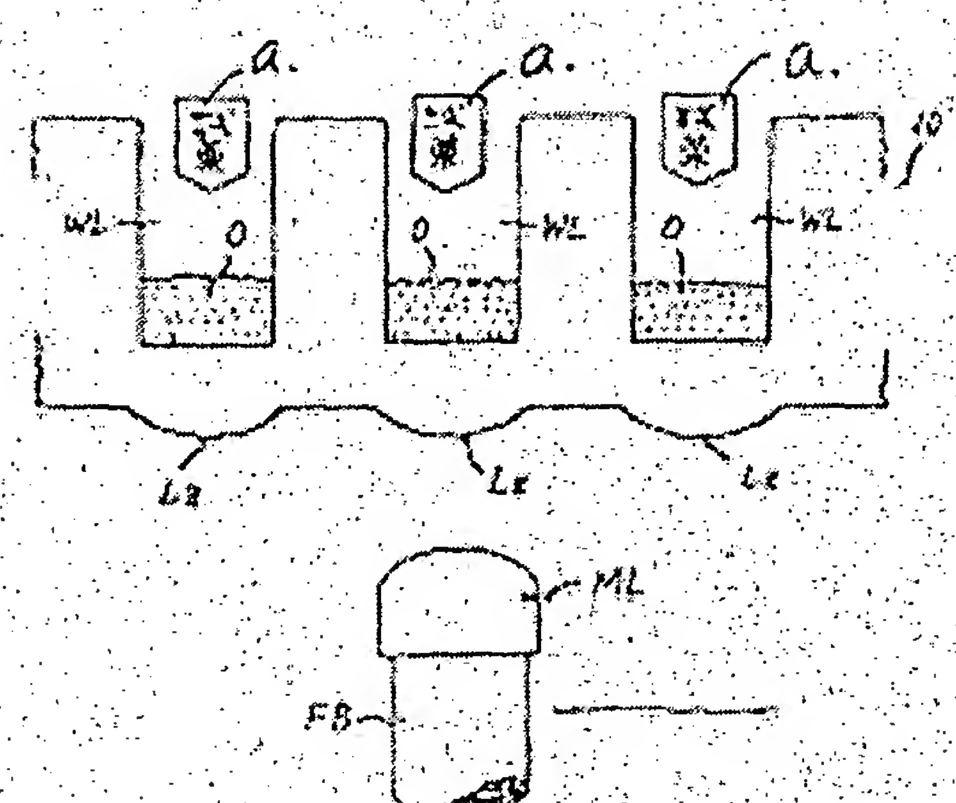
[Key]
a. Type

[Fig.4]



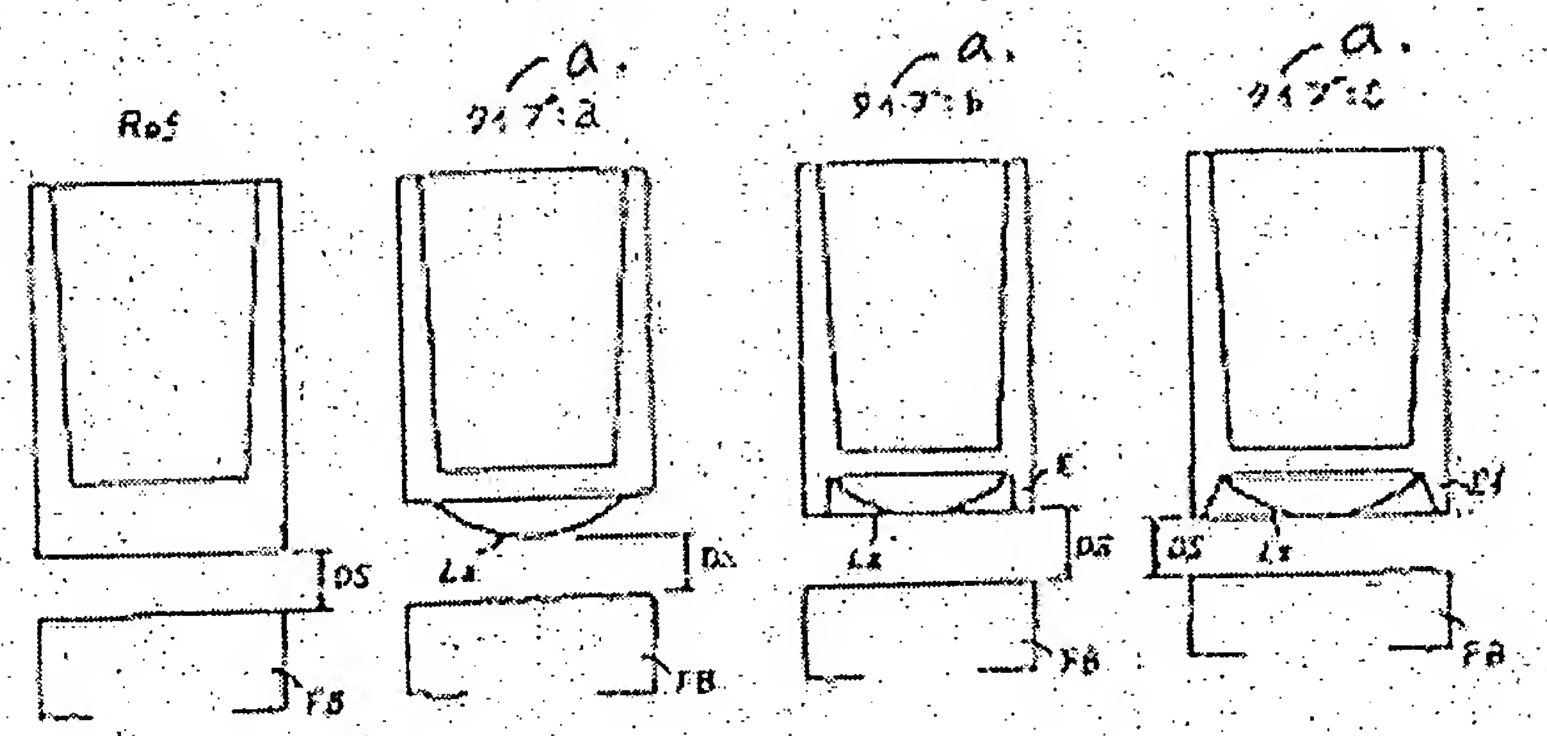
[Key]
a. Sample

[Fig.5]



[Key]
a. Sample

[Fig. 6]



[Key]
a. Type

Continue from front page:

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